MTR

Field Demonstration of a Membrane Process to Recover Heavy Hydrocarbons and to Remove Water from Natural Gas

2005 Annual Report

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by

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ANNUAL PROGRESS REPORT

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Disclaimer

Abstract

The objective of this project is to design, construct and field demonstrate a membrane system to recover natural gas liquids (NGL) and remove water from raw natural gas. An extended field test to demonstrate system performance under real-world high-pressure conditions is being conducted to convince industry users of the efficiency and reliability of the process. The system was designed and fabricated by Membrane Technology and Research, Inc. (MTR) and installed and operated at BP Amoco's Pascagoula, MS plant. The Gas Research Institute is partially supporting the field demonstration and BP-Amoco helped install the unit and provided onsite operators and utilities. The gas processed by the membrane system meets pipeline specifications for dewpoint and BTU value and can be delivered without further treatment to the pipeline. Based on data from prior membrane module tests, the process is likely to be significantly less expensive than glycol dehydration followed by propane refrigeration, the principal competitive technology. During the course of this project, MTR has sold 11 commercial units related to the field test technology, and by the end of this demonstration project the process will be ready for broader commercialization. A route to commercialization has been developed during this project and involves collaboration with other companies already servicing the natural gas processing industry.

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1. INTRODUCTION

The objective of this project is to design, construct and field demonstrate a membrane system to recover natural gas liquids (NGL) and remove water from raw natural gas. An extended field test to demonstrate system performance under real-world high-pressure conditions is being conducted to convince industry users of the efficiency and reliability of the process. The system was designed and fabricated by Membrane Technology and Research, Inc. (MTR) and installed and operated at BP Amoco's Pascagoula, MS plant. The Gas Research Institute is partially supporting the field demonstration and BP-Amoco helped install the unit and provided onsite operators and utilities. The gas processed by the membrane system meets pipeline specifications for dewpoint and BTU value and can be delivered without further treatment to the pipeline. Based on data from prior membrane module tests, the process is likely to be significantly less expensive than glycol dehydration followed by propane refrigeration, the principal competitive technology. During the course of this project, MTR has sold 11 commercial units related to the field test technology, and by the end of this demonstration project the process will be ready for broader commercialization. A route to commercialization has been developed during this project and involves collaboration with other companies already servicing the natural gas processing industry.

2. PROGRESS FROM SEPTEMBER 30, 2004 - SEPTEMBER 29, 2005

The MTR membrane system was installed at the BP Amoco Pascagoula gas processing plant during 2004. The plant was undergoing a very significant expansion in capacity and the installation of the membrane unit did not begin until late in the third quarter of 2004. The system startup and initial testing began in February 2005. After a few days of operation, permeate pressures increased, and a decision was made to replace the membrane modules with newer modules. Plant upgrades at Pascagoula and some minor delays due to the Gulf Coast hurricane season postponed our re-start until September 2005. The performance of the membrane unit during the first week of operation was exactly as predicted by our models, and we now anticipate running the unit for several additional months. A photo of the MTR membrane unit at Pascagoula is provided in Figure 1.

Summarizing our commercialization efforts during this report period, significant progress was made toward introducing MTR's NGL membrane and systems into the natural gas market. Two FGCU units came on-line in early 2005: the Plains Exploration System in Bakersfield, CA and the Star Energy System at Kakap - H Platform in Indonesia. We also sold two new FGCUs to Sid Richardson Exploration Co. for installation at two compressor stations in remote New Mexico locations. We received the order in June 2005, and the units started up in October with results that met or exceeded the guaranteed performance. Figures 2 and 3 provide photos of the two New Mexico units. Sales of hydrocarbon-selective membrane systems in natural gas FGCUs now number eleven, and orders are open for several additional units worldwide.

Figure 1. MTR's field demonstration membrane-based gas treating unit at BP Amoco's gas processing plant in Pascagoula, MS. The membrane unit was installed in late 2004; start-up and testing began in February 2005.

Figure 2. Fortson plant fuel gas conditioning skid in New Mexico; the plant processes fuel for a Waukesha engine.

Figure 3. Nashdraw plant fuel gas conditioning system for fuel to a Superior gas engine. The system is located in New Mexico.

The work accomplished during the period September 30, 2004-September 29, 2005 is summarized by task below.

Task 4.0 Develop Field Test Plan

We began continuous field tests in third quarter 2005, and we currently anticipate a six-month testing period. The time may be extended if the BP Amoco plant continues to provide support of day-to-day operating expenses.

The anticipated field test plan is summarized in Table 1.

Table 1. Test Plan for NGL Field Demonstration

Month	Testing Protocol	MTR Personnel Involvement	Status
1	Startup/solving teething issues in the unit. Initial testing at available plant conditions	Yes (1 week). Daily data collection and analysis of all key streams	Complete
2	Parametric testing of variation in pressure and flow rate	Yes (1 week). Pressure variation: 500 – 1000 psia Flowrate variation: 1-3 MMSCFD	Complete
3	Continuous operation at available plant conditions	No	Ongoing
4	Continuous operation at available plant conditions	Yes (1 week). Daily data collection and analysis of all key streams	Ongoing
5	Continuous operation at available plant conditions	No	Planned
6	Parametric testing of variation in pressure and flow rate	Yes (1 week). Pressure variation: 500 – 1000 psia Flowrate variation: 1-3 MMSCFD	Planned

The above table gives a broad outline of the activities scheduled for the system at Pascagoula. Our previous experience in performing such field demonstrations has shown that variation of various key parameters over as wide a range as desired is not often possible due to the potential disruption in operations that would result at the client facility. For example, the above estimates of the variations in pressure and flowrates for Months 2 and 6 are based on our desired testing ranges, given the streams available at the test site. In fact, the pressure variations we obtained in Month 2 varied only from 700-900 psig.

Task 5.1 Prepare Membranes and Modules

This task was completed in 2003.

Task 5.2 Design and Construct Field Demonstration System

This task was completed in 2003. Some field modifications had to be made in 2004 in order to comply with the plant specifications, which were provided to us once the unit was in place at the BP Amoco facility.

Task 5.3 Install Systems at Site/Initial Evaluation

The installation of the membrane unit and the compressor finally commenced in the third quarter of 2004. The system was hooked into the plant lines and all required electrical cable runs, motor start-ups, PLC, and related activities were completed by the end of 2004.

Task 5.4 Operate System Continuously

The system was commissioned in February 2005, but was performing below expectations within a few days. A decision was made to replace the membrane modules, so new modules were prepared while plant upgrades were being performed at Pascagoula. A restart in September 2005 was quite successful in its first week, and after some small changes in filters and level controllers were made, the system was restarted again for longer-term, continuous high-pressure testing. Necessary permits are being renewed that will allow us to test for up to an additional year; we expect the testing to last at least six months.

Task 5.5 Survey Industry Users/Analyze Economics

As mentioned in our previous reports, we have identified the following three applications relevant to this project as focus areas in terms of commercialization of the technology:

- fuel gas conditioning (gas engines and turbines)
- NGL recovery from rich associated gas streams (upto 15 MMSCFD)
- gas processing for dewpoint control (up to 20 MMSCFD).

We have continued to pursue the development of these applications and have acquired significant insights in both the technical and marketing areas. Based on this knowledge, MTR and ABB Lummus Global (our commercialization partner in the gas processing product area) have developed various strategies and tactics to address what we have learned are key requirements of the customers. In particular, we have

- Developed a standardized layout and membrane skid to lower repetitive engineering costs and to develop essentially reusable systems.
- Developed a detailed package of system specifications to allow rapid transfer of information to potential clients.
- Built a network of fabrication shops and contacts to minimize building costs and accelerate delivery schedules.

Completing all of these tasks has allowed the MTR-ABB alliance to quickly come up with skid pricing and also to generate proposal documents for potential clients in a rapid manner.

Task 5.6 Develop Commercialization Plan

Most of our 7-point commercialization plan was developed during the previous reporting periods. We are finding our alliance with ABB Lummus Global (Randall Gas Technologies Division) to be particularly useful and suitable to market development in the natural gas processing arena. Specifically, we have already built and installed several commercial FGCU units for use in remote gas processing locations, and continue to receive inquiries and orders from companies worldwide in this product area. We will be presenting summaries of our FGCU progress at the Spring 2006 Laurance Reid Gas Processors' Conference; several pertinent slides that highlight developments during this DOE reporting period are attached as Appendix A.

In pursuing the commercialization of MTR's technology for membrane-based gas conditioning, we determined that several key issues had to be tackled in order to successfully push the technology into general use in the natural gas market. The following section summarizes the major issues we are addressing in our commercialization plan, including pertinent examples from this year's commercialization efforts. The issues include:

1. Access to markets and consistent collection of valid qualified leads and prospects related to the focus applications

Developing access to the market has been attempted through several initiatives. MTR formed a marketing alliance with ABB Lummus Global – Randall Gas Technologies in 2002. Our recent commercialization efforts with ABB are described in more detail in Task 5.5 above.

We also attempted to set up alliances with industry-specific suppliers; for example, gas engine manufacturers such as Caterpillar and Waukesha. Since their engines could perform better in many remote site environments with the use of MTR membranes for gas conditioning, it was expected that they would be receptive to our overtures. We, discovered, however, that gas engine manufacturers do not want to add anything to their scope of supply or performance for fear of having a higher overall initial price, which in their opinion could cause them to lose the initial bid. They have informed us that they will let the final client know that to use the gas engines, the gas has to meet a certain specification, but that it is the final client's responsibility to determine how such a specification can be met.

Due to this reluctance on the part of the gas engine manufacturers to accept and incorporate membrane-based gas conditioning systems, we changed this portion of our market access strategy. We are currently marketing directly to the end users as our clients. Specifically, we are trying to locate those clients that are having problems with their gas engines due to fuel gas conditioning problems. By locating such potential clients and showcasing our product as a problem-solving tool, we expect to be able to convince clients to buy the membrane system to alleviate their problems. We have already seen some success in this approach and continue to expand our reach to such clients.
This approach is also helping us build a portfolio of various engine types and situations to which our products can be most successfully applied.

2. Ability to provide a technically adequate solution for the problem

In the case of fuel gas conditioning, we have determined that our solution works best for applications in remote locations, such as close-to-the-wellhead units or offshore and floating (FPSO) platforms. At such locations, good quality gas is not available and the client has to use the only gas available at the site, which is typically low grade. With this technical and market knowledge, we are able to focus our commercialization effort into the most productive areas. Both the North Sea unit for Statoil that was installed in 2004 and the Kakap-H Remote Platform unit for Star Energy that was installed in Indonesia in 2005 are good examples of the suitability of our units for platform use. Examples of the conditioned fuel gas upgrades obtained at these two units are provided in Appendix A.

3. Ability to inspire confidence in the customer and an adequate comfort level with the new technology

Since we have installed our first several units, we are seeing more and more receptiveness in our clients to use the membrane process as a fuel gas conditioning solution. The new Sid Richardson installations are an excellent example. Richardson made the decision to incorporate the reverse-selective membrane FGCUs at the same time that new engine/compressor sets were installed at the site. Both these units have been operating at better than guarantee, even though the gas being conditioned was richer than the design values (see the Sid Richardson description in Appendix A for additional performance details).

4. Ability to correctly price the systems to meet customer expectations and expected competition

We continue to work on this aspect of our marketing and business approach in order to deliver solutions that are commercially acceptable to clients. Our current understanding is that for retrofit installations in which we are fixing an existing problem, the pricing flexibility is significantly greater than for new installations in which the client is trying to ward off or anticipate a potential future fuel problem.

5. Ability to deliver a system in the shortest possible elapsed time from placement of order

Timely delivery has been consistently noted as an important factor in all our commercialization efforts. Typical delivery times requested by customers are 12-14 weeks from placement of order, which we met with the Sid Richardson order this summer. In order to address elapsed time issues, we are upgrading our membrane and module manufacturing and also devising better engineering approaches that minimize the delivery schedule and meet client expectations.

6. Ability to predict and control costs to ensure profitability

We have standardized our costing datasheets, and now have gained a much higher level of experience in costing the system from our proposal preparation and sales efforts. We are getting more and more comfortable in predicting the cost of systems to ensure consistent and predictable profitability on projects.

7. Ability to provide final client with innovative financing methods, including leases and processing fees.

This is an aspect we are working on with our partners at ABB. The current consensus is that we need to have several additional operating systems in the field, each operating efficiently under design conditions, before we consider innovative financing arrangements for clients.

MTR's marketing efforts have been focused on the best possible utilization of our website www.mtrinc.com. The website approach has produced the most consistent results in generating high quality leads and inquiries for sales of fuel gas conditioning units. All systems sales related to this project have been developed starting from our website marketing efforts. We continue to generate between 12 and 15 inquiries every week from our website.

Task 6.0 Final Report/Conference Presentation

ABB/MTR made two conference presentations in 2004, the first one at the prestigious Laurance Reid Gas Conditioning conference in Oklahoma and the second at the Annual GPA conference in New Orleans. We have been invited to present at these two meetings again in March 2006, and will do so.

The final report for this project will be prepared when the Pascagoula high-pressure test work is completed this coming year.

3. CONCLUSIONS

There have been two distinct parts to this demonstration project. The first part involved building, installing, and testing a demonstration plant for NGL separation and recovery and the second part involved commercialization activities. While the first part of the project has seen many unavoidable delays due to the various requirements and delays at the host site, the first tests started in 2005. We expect to run the unit for at least a few months in 2006 to accumulate high-pressure separation data. BP Amoco has indicated a willingness to continue working with us at the test site through 2006, providing opportunities to use Pascagoula as a performance demonstration site as well.

The second portion of the project, the commercialization of the technology, has progressed very well. We have sold and installed several commercial units using the membrane technology developed in this project and these installations have been operating satisfactorily for their clients. We attribute part of this success to our efforts at firming up our processes and procedures for commercialization of the technology and implementing them. In particular, our website marketing strategy is yielding very good results in leads generation. We delivered four more fuel gas conditioning units in this reporting period, and we expect to see the momentum of these activities build up as more and more units are installed, resulting in greater customer confidence.

4. REFERENCES

1. Pat Hale, Randall Gas Technologies-ABB Lummus Global Inc, and Kaaeid Lokhandwala, Membrane Technology and Research, Inc., "Advances in Membrane Materials Provide New Solutions in the Gas Business", presentation at Laurance Reid Gas Conditioning Conference (LRGCC), University of Oklahoma, Norman, OK, February 27-March 3, 2004.

2. Pat Hale, Randall Gas Technologies-ABB Lummus Global Inc, & Kaaeid Lokhandwala, Membrane Technology and Research, Inc., "Advances in Membrane Materials Provide New Solutions in the Gas Business", presentation at 83rd GPA Annual Meeting, New Orleans, LA, March 13-16, 2004.

3. Kaaeid Lokhandwala, Ankur Jariwala, and Richard W. Baker, R.W., "Only raw sour gas available for engine fuel? Proven membrane process cleans gas for engines," to be presented at *The 56th Laurance Reid Gas Conditioning Conference*, Norman, OK, February 27 - March 1, 2006.

4. Kaaeid Lokhandwala, Ankur Jariwala, and Richard W. Baker, R.W., "Only raw sour gas available for engine fuel? Proven membrane process cleans gas for engines," to be presented at *Gas Processors' Association (GPA) Annual Meeting,* Grapevine (near Dallas), TX, March 5-8, 2006

Appendix A: Selected Field Experience Data and Photos for Membrane FGCUs

- Kakap-H Remote Platform A-1
  Star Energy, Indonesia

- Three-Engine Gen-set on Petrojarl - I (FPSO) A-3
  Statoil (PGS) – North Sea

- Superior and Waukesha Engines Fuel Gas Conditioning A-5
  Sid Richardson, New Mexico (2 Units)

The following pages summarize performance data and provide photos for MTR FGCUs installed during this DOE reporting period. The information is from a presentation to be given at the 2006 Laurance Reid Gas Conditioning Conference.

Kakap-H Remote Platform
Star Energy, Indonesia

Stream Components	Gas Compositions	
	Feed Gas (mol%)	Conditioned Fuel Gas (mol %)
Propane	4.60	1.48
i-Butane	1.97	0.52
n-Butane	1.53	0.30
Pentanes	1.74	0.28
Hexane	1.05	0.126
C_{6+}	0.91	0.078
Balance Methane and Ethane		
Total C_{3+} Hydrocarbons	**11.76**	**2.78**
METHANE NUMBER	**16**	**71**

cknowledgement: Data Provided by Mr. Zikri Syah, Star Energy

Kakap-H Remote Platform
Star Energy, Indonesia

Three-Engine GenSet on Petrojarl - I (FPSO) Statoil (PGS/Wartsila) – North Sea

Stream Components	Inlet Feed (mol%)	Conditioned Fuel Gas (mol%)
Methane	72.94	86.95
Ethane	9.73	5.68
Propane	8.51	3.18
Butanes	5.05	1.10
Pentanes	1.63	0.30
Carbon Dioxide	0.40	0.25
Nitrogen	1.22	2.49
N-Hexane	0.52	0.06
METHANE NUMBER	**32**	**65**
Pressure (bar)	13.8	10.3
Volume (MMSCFD)	5.5	1.8

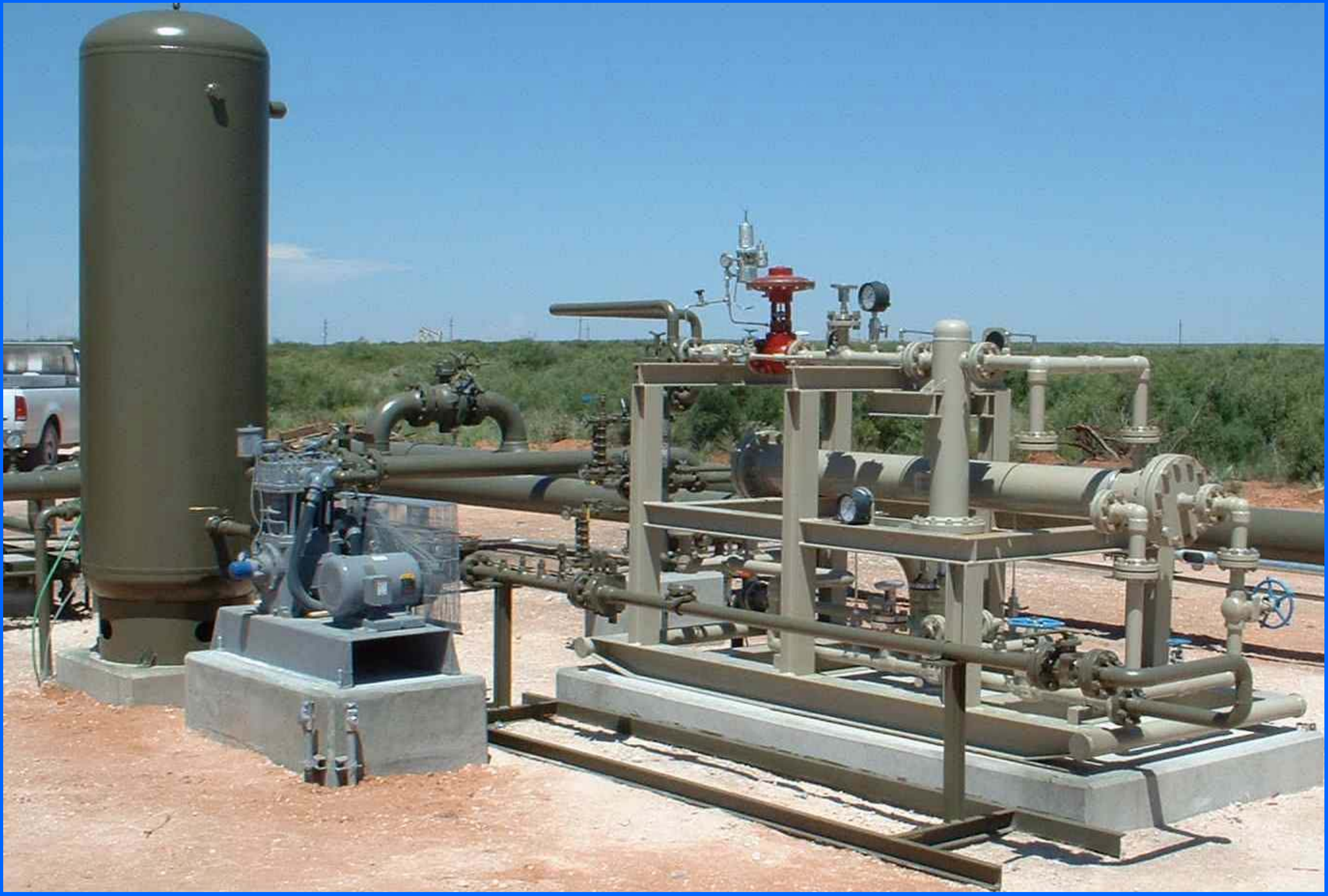
Three- Engine Gen-set on Petrojarl - I (FPSO) Statoil (PGS/Wartsila) – North Sea

Superior and Waukesha Engines Fuel Gas Conditioning
Sid Richardson, New Mexico

Stream Components	Design Inlet Feed (mol%)	Guaranteed Conditioned Fuel Gas (mol%)	Actual Inlet Feed (mol%)	Actual Conditioned Fuel Gas (mol%)
Methane	73.3	81.99	69.58	81.19
Ethane	10.89	6.93	11.23	6.89
Propane	6.00	2.63	6.53	2.35
Butanes	2.55	0.56	2.53	0.66
Pentanes	1.07	0.2	0.77	0.16
Carbon Dioxide	1.63	0.85	4.67	3.07
Nitrogen	3.71	6.69	4.05	5.41
N-Hexane	0.83	0.126	0.37	0.07
METHANE NUMBER	**39**	**67**	**44.4**	**68**

knowledgement: Data Provided by Gary McCoy, Sid Richardson, Dallas, TX

Superior Engine Fuel Gas Conditioning
Sid Richardson, New Mexico (Nashdraw Unit)



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A. CONTRACTOR ACTION (CONTRACTOR COMPLETES PART A. 1-5)

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2. Type of Document: ☒ Technical Progress Report ☐ Topical Report ☐ Final Technical Report
☐ Abstract ☐ Technical Paper ☐ Journal Article ☐ Conference Presentation
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Yes	No	
☐	☒	Is any patentable subject matter disclosed in the report?
☐	☐	If so, has an invention disclosure been submitted to DOE Patent Counsel? If yes, identify disclosure number or DOE Case Number ______
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♦5. Signed ______ (Contractor) Date March 15, 2006

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B. DOE PATENT COUNSEL ACTION

☐ Patent clearance for release of the above-identified document is granted.
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